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(54) The multi-functional vertical tube biological reactor

(57) The multi-functional vertical tube biological reactor, based on the optimum of hydraulic, gases kinetics and microbiological conditions, gives the high efficiencies in the waste-water biological treatment, industrial fermentation, and other bio-engineering. It is composed of some basic units having the tube-like or tower-like structures. In the reactor, the gas and liquid are well mixed and their contact time can last as it needs. The vertical installation of the reactor save the construction floor. In the same device, the aerobic, anaerobic, suspended growing and fixed growing of the microbe can all be performed. The higher oxygen transport efficiency, energy-save stirring, easy management, lower operation cost and systematically manufacture properties are quite striking.

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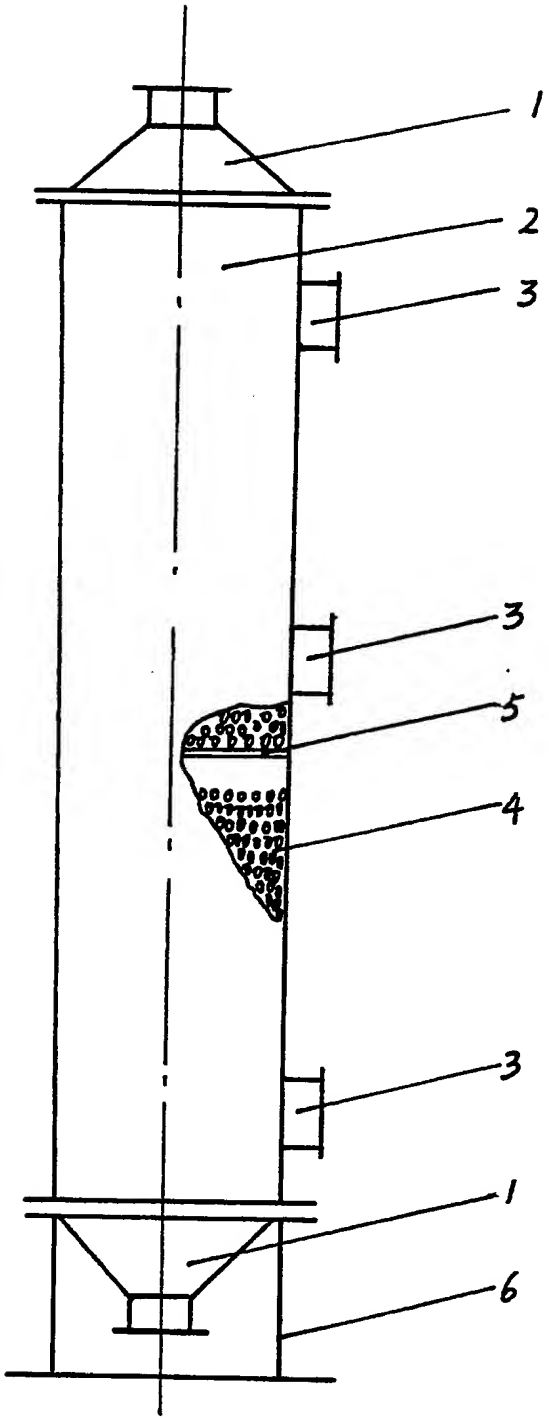

Fig. 1

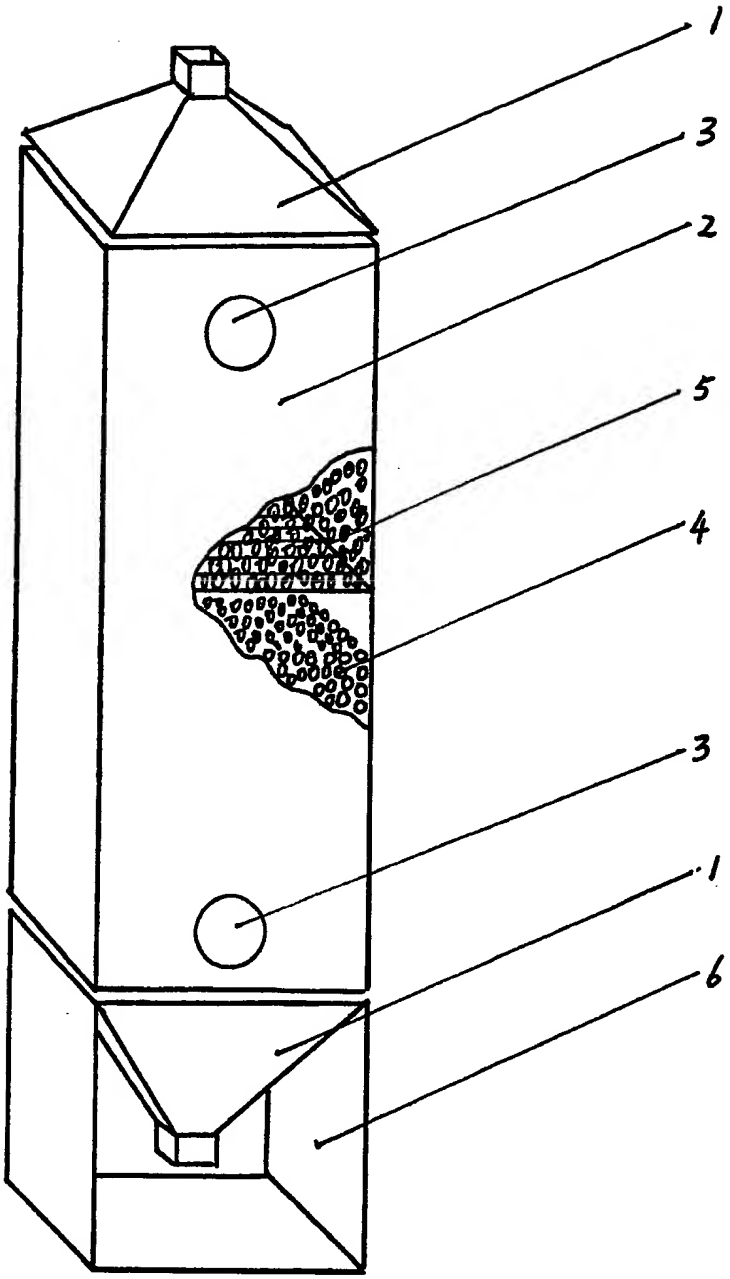

Fig. 2

THE MULTI-FUNCTIONAL VERTICAL TUBE BIOLOGICAL REACTOR

This invention relates to a series of devices in the environmental engineering and biological engineering processes.

Using microbes for the benefits, so-called bio-engineering, is most attractive industry nowadays and in the future. The biological reactor is the essential device for this process,of course, and many of them have been constructed in the world. At the view-point of bio-engineering, all of these reactors are catalogued as: suspended growing and fixed growing of the microbes; and both of them can be further divided into aerobic, anaerobic, and mid of them. At present, all of these six big groups of bio-reactors have always been manufactured in the separate methods and different structures to meet the needs of microbe growing. people think that they are so much different and there is no way to have one kind of reactor work in those different conditions.

This invention will give a series of, having the same structure, devices which can be applied in any kind of situations mentioned above.

Unlike the traditional bio-reactors: the tanks, the ponds, the wells, —, this new kind of bio-reactor is composed of tubes(when the diameter is smaller) or towers (when the diameter is larger); it is also characterized by the vertical stand of tubers or towers and vertical turn-flow of the liquid and gas(if needed); the third and most important specification is that the liquid and gas always flow in the same direction, even in the downward, which give the gas-liquid contact time for some minutes or more; the fourth is its outstanding advantage that it always takes the full use of fixed growing technology in the proper stage and no big microbe separation work left.

The device is composed of several basic units, which has the structure shown as fig.1 or fig.2. The unit includes the covers 1, the wall 2, the repairing holes 3, the inside packing 4, their support plate 5, and the support 6. The unit cross section can be cylinder(as fig.1),square(as fig.2), and other shapes, the diameter(or equivalent diameter) can be 0.2--20 m; the height can be 2--30 m; the materials to made the unit can be the steels and their alloys.engineering resins, engineering plastics, and concrete; the packing used(if necessary) can be made of any kind of steels,plastics,potters,and fibres; the oxygen sources(for aerobic condition) can be air(microbe-free or not according to the production process),oxygen-rich gas, and pure oxygen; the gas supply methods can be vacuum jetting, low pressure blower, high pressure blower, high pressure oxygen bottle, and oxygen producer; the operation pressure of the unit can be 0--1.5 M.Pa; the oxygen-free gas can be used as stirring gas in anaerobic condition. and the most economic way is using the gas produced by the microbes; the amount of unit to form the device can be 2--30, according to the production processes, it could be system designed; the combination methods of the units can be separate(connected with pipes) and compacted(especially for square shape and/or constructed with concrete).

The application in the waste-water treatment processes can be expressed as follows:

1.Aerobic biological treatment device:

At the optimum conditions,the oxygen efficiency can be 90%; the oxygen transport efficiency can be 2--4 kgO_2/KWH; the oxygen supply capacity is 0.5--1.0 $kgO_2/m^3.hr$.

2.Anaerobic biological treatment device:

The oxygen-free gas stirring with no increased expense resulting in low operation cost; the sealed reactor easy to methane recovery; the sludge digestion,the flux bed,and the fixed film all being properly set in the different stages which gives the high efficiency; the only consumption being the pump to send the water into the device.

3.Anaerobic-aerobic serial treatment device:

Only by changing the operation method, the device mentioned above can form the anaerobic-aerobic serial device. It can perform well for high concentration organic waste-water ,with BOD_5(5 days Biochemical Oxygen Demand) up to 20,000 mg/l or more. Of course, it could be used in the fermentation,one of the most popular bio-processes.

4.Anaerobic-aerobic-anaerobic serial treatment device:

Just as mentioned above, this process could be easily formed and used in Nitrogen,Phosphorous removal,and then the eutrophication could be eliminated. The other important application is sludge elimination, at proper condition, the extra sludge of this device could be near zero and no sludge treatment process is needed.

5.For its application fields, followings can be summarized: the municipal sewage, organic synthesis plant waste-water, coking plant and gas works effluent, oil-refinery and petro-chemical plant discharges, dye manufacturer and dyeing works waste-water, fermentation processes waste and so on. In an other words, if the waste-water having the BOD_5/COD_{Cr}(Chemical Oxygen Demand determined by Potassium Dichromate) ratio 0.2--0.8 or even low,and BOD_5 at 50--20,000 mg/l or even high, they are all treatable by this kind of device.

6.For its low cost, these parameters can be combined: the construction floor is only one fourth or one fifth of that of the activated sludge process needed; the electricity consumption is about 0.35 KWH/M^3,water; the sole rotating machine is the pump with or without an air blower(or compressor), please note that even at the aerobic conditions there may be without air blower; finally, the operation is easy and just one or two person(s) is enough no matter 100 ton/hr or 1000 ton/hr waste-water being treated, so do the biological production processes.

7.One thing should say is that the applications mentioned above just are examples, there are many other combination methods of the units, which can give the characteristics of the device for universal applications.

The example of the aerobic waste-water treatment device can be stated as follows: the waste-water ,stored in the adjust pond, is pumped into the jet and mixed with gas.then, got into the reactor; the microbes fixed on the packing degrade the pollutants, and the waste-water is purified; the cleared water exits after the liquid-gas separation stage and the expended gas exits from the outlet of the reactor. For the water treatment capacity of 10 m^3/hr, with the BOD_5 value of 1060 mg/L,supposing the discharge water with the BOD_5 value of 60 mg/L,the BOD_5 removal load is 10 kg/hr. The reactor, with the total volume of 80 m^3, is employed, and then the unit BOD_5 removal load is 3 kg/m^3,day. The hydraulic retention time is 8 hours, the reactor has 10 units, with the diameter 1.0 m and the height 10 m. The gas-liquid contactor time is 8.9 minutes and gas/liquid can be low as 3/1.

CLAIMS

1. A multi-functional vertical tube biological reactor is composed of some basic units; each unit includes its covers, walls, repair holes, inside packing, their support plates and unit support; the height of each unit can be 2--30 m; the diameter of the unit can be 1--20 m and different diameters can be combined in to one device; the amount of the unit needed in one device can be changed from 2 to 30, mostly according to the height of the unit and the production processes;the unit can be made of any kind of steels or their alloys,engineering plastics, engineering resins, and concrete; the combination methods of the unit cab be separate or compacted.

2. The reactor claimed in claim 1 is characterized as: the unit can load with packing or without packing in some cases; the packing (if needed) can be made of any kind of steels or their alloys, plastics, potters, fibres; the shapes of the packing can change according to the diameter of the unit and be different in one device; the gas ,in aerobic condition, supplies can be air, oxygen-rich gas, pure oxygen and be supplied by water jet, blower, oxygen bottle, and oxygen producer; the gas ,in anaerobic condition, cab be any kind of oxygen-free and harmful-free gas for gas stirring, especially by using the bio-gas produced in the process.

3. The reactor claimed in claim 1 and claim 2 is characterized as: the operation pressure of the unit can be changed from 0.1--1.5 MPa, and different unit can be worked in the different pressures; the temperature will be 10--60 degree centigrade and change according to the productions.

4. The reactor claimed in claim 1, claim 2, and claim 3 is characterized as: when used in the aerobic condition, the dissolved oxygen can be 0.5--5.0 mg/L; the change is needed for the different oxygen demands and is performed by altering gas/liquid ratio; the gas-liquid contact time can be 5--30 minutes which can be altered by unit height and unit number and this time will give the influence of oxygen efficiency accompanied with the operation pressure; for getting well mixing of gas and liquid, the flow direction of the fluid will be vertical changed for 2--30 times; the key point is that the flow rate of the liquid must great than the up-speed of the gas bobbers when the fluid flow in the downward; the packing are needed for most of the processes but the kinds of the packing have a big choice.

5. The reactor claimed in claim 1, claim 2, and claim 3 is characterized as: when used in the anaerobic condition,the hydraulic retention time can be 8--48 hours according to the processes; the diameter within 5 meter is preferable to get good stirring efficiency; the bio-gas, produced in the process, recycled for stirring is the most important character, of course, other oxygen-free and harmful-free gas is available.

6. The reactor claimed in claim 1, claim 2, and claim 3 is characterized as: by altering the gas supply position of the reactor, it can easily form the anaerobic-aerobic serial device; it is very suitable for the higher organic load production and for special microbes; because of its higher microbe productivity, first one or two unit(s) can be packed with high space packing or without packing; the statements about each stage in the claim 4,claim 5 are all valid in this claim.

7. The reactor claimed in claim 1, claim 2, and claim 3 is characterized as: by altering the gas supply and exit positions of the reactor, it can easily form the anaerobic-aerobic-anaerobic serial device; this device is very useful in waste-water treatment(for nitrogen,phosphorous removal,sludge digestion) and some industrial fermentation processes; the hydraulic retention time for each stage can be freely set at its optimum condition by changing the diameter and the number of the units employed; the statements about each stage in claim 4,5,6 are all valid in this claim.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	-6-	Application number GB 9306876.5
Relevant Technical Fields (i) UK Cl (Ed.M) C1C (CTBA, CTBB, CSBA, CSBB, CRBA, CRBB) (ii) Int Cl (Ed.5) C02F		Search Examiner R HONEYWOOD Date of completion of Search 14 JUNE 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE WPI		Documents considered relevant following a search in respect of Claims :- 1-7

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Category	Identity of document and relevant passages		Relevant to claim(s)
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X	GB 2198123 A	(ASHBROOK-SIMON-HARTLEY INC)	1 AT LEAST
X	EP 0070960 A1	(BAYERISCHE MILCHINDUSTRIE EG)	1 AT LEAST
X	EP 0025597 A1	(SCHREIBER)	1 AT LEAST
X	WO 83/02770 A1	(WESTERMAIR)	1 AT LEAST
X	US 4551250 A	(LINDE AG)	1 AT LEAST
X	WPI ACCESSION NO: 86-287499/14 AND JP 61209089 A (SHIMIZU CONSTRUCTION) see abstract		1 AT LEAST
X	WPI ACCESSION NO: 84-127996/21 AND DD 206365 A (VEB PKM ANLAGENBAU)		1 AT LEAST

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